

INDOOR AIR QUALITY ASSESSMENT

**Lynnfield Middle School
505 Main Street
Lynnfield, Massachusetts 01940**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
August 2006

Background/Introduction

At the request of a parent and the Lynnfield Public School Department, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at each of Lynnfield's public schools. These assessments were jointly coordinated through Patti Fabbri, Parent/IAQ Representative, Thom Forbes, Facilities Manager, Lynnfield Department of Public Works and Jim Nugent, Director, Lynnfield Health Department.

On May 11, 2006, a visit to conduct an assessment of the Lynnfield Middle School (LMS) was made by Cory Holmes, an Environmental Analyst in the CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied for portions of the assessment by Ms. Fabbri and Mr. Forbes.

The school is a two-story red brick building constructed in 2003. The second floor is made up of general and science classrooms. The first floor contains general classrooms, science classrooms, kitchen, cafeteria, library, gymnasium locker rooms, music rooms, art rooms, computer rooms and office space.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Hnu, Model 102 Snap-on Photo Ionization Detector (PID). CEH staff also

performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 700 students in grades 5-8 and approximately 65 staff members. Tests were taken under normal operating conditions; however several classrooms were unoccupied due to end of the year activities. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from the Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in twenty-four of forty-nine areas surveyed, indicating poor air exchange in about half of the areas surveyed, mainly due to mechanical ventilation components being deactivated or inoperable at the time of the assessment. It is also important to note that a number of areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied or had windows open. Low occupancy and open windows can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and with windows closed.

Fresh air in classrooms is supplied by computerized unit ventilator (univent) systems ([Figure 1](#)). A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building (Pictures 1 and 2) and returns air through an air intake located at the base of the unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Adjustable louvers control

the ratio of outside to recirculated air. Some classrooms have univents installed above the ceiling that are ducted to classrooms via multi-directional air diffusers (Picture 3). Univents were found deactivated by occupants in a number of areas (Table 1). Obstructions to airflow, such as items stored on or in front of univents were seen in some areas. In order for univents to provide fresh air as designed, units must be activated while rooms are occupied and air diffusers should remain free of obstructions.

The mechanical exhaust ventilation system consists of ceiling-mounted exhaust vents (Picture 4) ducted to rooftop motors. Two rooftop exhaust motors, that service half the classrooms, were not functioning during the assessment. Without sufficient supply and exhaust ventilation, environmental pollutants can build up and lead to indoor air quality/comfort complaints.

Mechanical ventilation in common areas (e.g., gym, cafeteria, media center) is provided by air handling units (AHUs) located on the roof (Picture 5) or in a penthouse. Outside air is heated or cooled and distributed to occupied areas via ceiling-mounted air diffusers and ducted back to AHUs through return vents.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment, but should have occurred at some point after construction in 2003.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see [Appendix A](#).

Temperature measurements ranged from 72° F to 81° F, which were within the MDPH recommended comfort guidelines in all but two areas surveyed. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the

comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 41 to 54 percent, which was within the MDPH recommended comfort range in all areas surveyed during the assessment. The MDPH recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. During the heating season, relative humidity levels would be expected to drop below the recommended comfort range. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

Several areas had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can serve as a medium for mold and should be replaced after a water leak is discovered and repaired. Mr. Forbes reported that the building has had water infiltration issues through flashing, which the school department reportedly plans to address during the summer of 2006. Active leaks were reported in the health room (Picture 6), the music room (Picture 7) and in the stage area.

Plants were noted in several classrooms and in close proximity to univent air intakes outside the building (Picture 1). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources (e.g., air intakes, univent diffusers) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

Musty odors were reported in several classrooms along the front of the building, specifically rooms 113, 213, 103 and 203 (Figure 2). CEH staff detected a musty-odor along the front of the building as well as in these rooms during the assessment. The odors appeared to be emanating from wet mulch along the front of the building. The contour of the building forms two alcoves where these classrooms are located (Picture 8); mulch in the alcove does not dry completely due to lack of sunlight (Figure 2). In addition, plant and other debris was observed on the inner lip of univent air intakes (Picture 2). The design of the fresh air intakes allow for water and debris accumulation inside the grilles, which can in turn be drawn into univents and distributed into occupied areas.

Several classrooms contained aquariums and terrariums. Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth. A dehumidifier was observed in classroom 105. These reservoirs are designed to catch excess water during operation and should be emptied/cleaned regularly to prevent microbial and/or bacterial growth.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM_{2.5}) can produce immediate, acute health effects upon exposure. To determine whether combustion products

were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM_{2.5}.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND). Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM₁₀). According to the NAAQS, PM₁₀ levels should not exceed 150 microgram per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM_{2.5} standard requires outdoor air particle levels be maintained below 65 $\mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a).

Although both the ASHRAE standard and BOCA Code adopted the PM₁₀ standard for evaluating air quality, MDPH uses the more protective proposed PM_{2.5} standard for evaluating airborne particulate matter concentrations in the indoor environment. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. Outdoor PM_{2.5} concentrations were measured at 6 $\mu\text{g}/\text{m}^3$ (Table 1). PM_{2.5} levels measured in the school were between 4 to 15 $\mu\text{g}/\text{m}^3$, which were below outdoor measurements and the NAAQS of 65 $\mu\text{g}/\text{m}^3$ (Table 1). Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operation. Sources of indoor airborne particulate may include but are not limited to particles generated during the operation of fan

belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices, operating an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. In an effort to identify materials that can potentially increase indoor TVOC concentrations, MDPH staff examined classrooms for products containing these respiratory irritants. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were also found on countertops in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Several other conditions that can affect indoor air quality were noted during the assessment. In some classrooms items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

A number of exhaust/return vents and personal fans had accumulated dust (Picture 4). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Operate all ventilation systems throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to “high”.
2. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
3. Work with town/school officials to develop a preventative maintenance program for all HVAC equipment system-wide.
4. Remove all blockages from univents to ensure adequate airflow.
5. Close classroom doors to improve air exchange.

6. Consider adopting a balancing schedule of every 5 years for mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
7. Change filters for air-handling equipment as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
8. Use openable windows in conjunction with classroom univents and exhaust vents to increase air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
10. Continue with plans to make repairs to flashing to prevent further water infiltration.
11. Once repairs are made, replace water damaged ceiling tiles. Examine the area above and around water-damaged areas for mold growth. Disinfect areas with an appropriate antimicrobial as needed.
12. Move plants away from outside air intakes and univent air diffusers in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.

13. Consider discontinuing the use of mulch in alcove areas outside of rooms 103 (203) and 113 (213) to prevent the entrainment of musty odors.
14. Examine the feasibility of replacing or modifying the exterior of univent fresh air intakes to prevent the accumulation of moss and debris.
15. Clean and maintain humidifiers/dehumidifiers as per the manufactures instructions.
16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
17. Store cleaning products properly and out of reach of students.
18. Clean fans blades, exhaust and supply vents periodically to prevent excessive dust build-up.
19. Consider adopting the US EPA (2000b) document, “Tools for Schools”, to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: <http://www.epa.gov/iaq/schools/index.html>.
20. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website: http://mass.gov/dph/indoor_air.

References

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Picture 1



Univent Fresh Air Intake, Note Shrubberty in Front of Vent

Picture 2



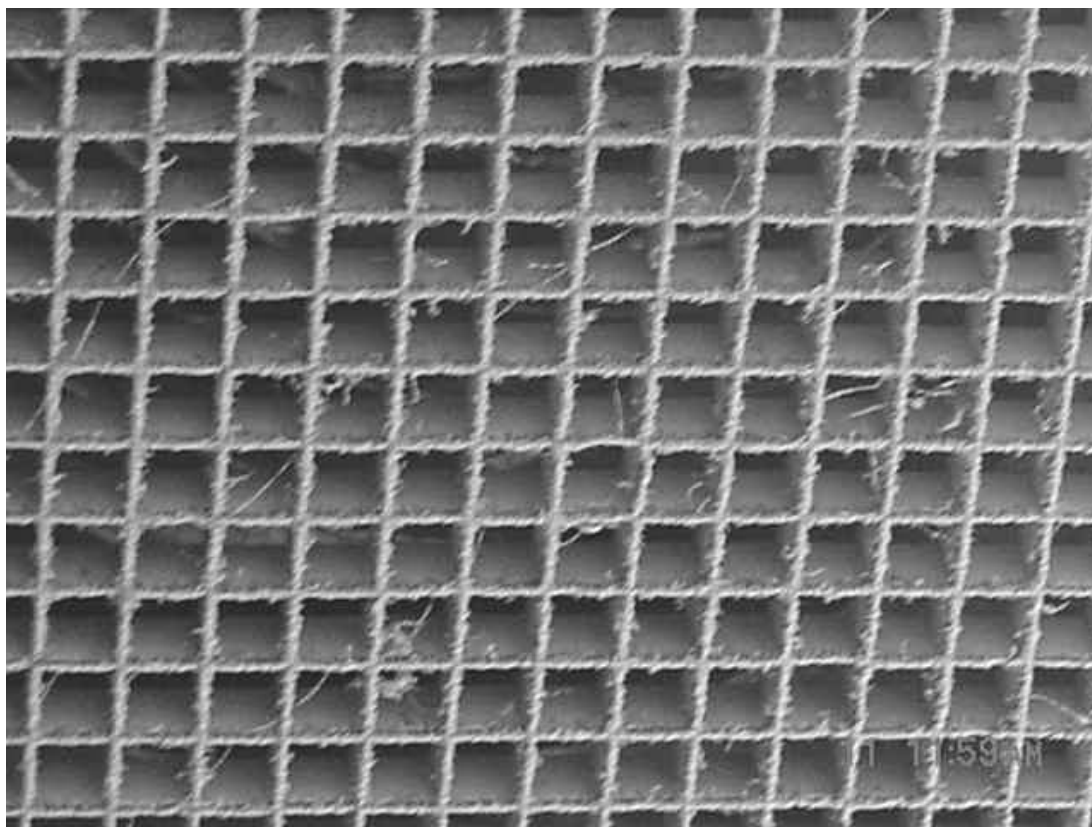
Univent Fresh Air Intake, Note Plant Debris in Intake Louvers

Picture 3



Ceiling Mounted Univent and Multi-Directional Air Diffuser

Picture 4



Ceiling-Mounted Exhaust Grill

Picture 5



Rooftop AHU

Picture 6



Missing/Water Damaged Ceiling Tiles in the Health Room (352)

Picture 7



Missing/Water Damaged Ceiling Tiles in the Music Room (373)

Picture 8



Mulch Bed in Alcove Outside of Classrooms 113/213

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		56	79	393	ND	ND	6				cloudy, drizzle.
201	19	75	53	828	ND	ND	9	Y # open: 2 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, PF.
200	11	76	43	750	ND	ND	8	Y # open: 0 # total: 1	Y univent	Y ceiling	Hallway DO, PF.
208	1	74	42	471	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, DEM.
207	27	74	44	752	ND	ND	10	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, #WD-CT: 1, DEM, PF.
206	29	74	44	723	ND	ND	11	Y # open: 0 # total: 4	Y univent plant(s)	Y ceiling (off)	Hallway DO,
204	30	78	46	1253	ND	ND	14	Y # open: 0 # total: 3	Y univent ceiling (off)	Y ceiling dust/debris	Hallway DO, DEM, deactivated reportedly due to noise.

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

G = gravity

GW = gypsum wallboard

M = mechanical

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

VL = vent location

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
227	0	81	41	770	ND	ND	15	N	Y ceiling	Y ceiling	Hallway DO, DEM.
202	28	78	41	888	ND	ND	8	Y # open: 0 # total: 3	Y univent	Y ceiling	Hallway DO, DEM, PF, cleaners.
203	25	77	42	729	ND	ND	10	Y # open: 0 # total: 4	Y univent	Y ceiling	DEM.
228	0	80	42	832	ND	ND	15	N	Y ceiling	Y ceiling	DEM, thermostat in adjacent room.
213	22	76	43	888	ND	ND	10	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, DEM, musty odors.
212	27	76	44	920	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	DEM.
211	26	77	44	1001	ND	ND	13	Y # open: 4 # total: 4	Y univent	Y ceiling (off)	Hallway DO, DEM, PF.

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									Supply	Exhaust	
210	1	75	43	522	ND	ND	6	Y # open: 0 # total: 1			Hallway DO.
218	22	74	45	781	ND	ND	8	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, PF, cleaners.
217	26	75	44	746	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling	DEM, PF, plants.
240	8	77	43	731	ND	ND	6	Y # open: 0 # total: 2	Y univent	Y (off)	PC, return vent disconnected.
SPED	0	75	43	692	ND	ND	7	N	Y ceiling	Y ceiling	DEM.
conference room	4	75	43	727	ND	ND	7	N	Y ceiling	Y ceiling	DEM, complaints of stuffiness.
103	27	77	51	1531	ND	ND	14	Y # open: 2 # total: 4	Y univent (off)	Y ceiling	DEM, plants, musty odors.

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									Supply	Exhaust	
102	0	75	45	553	ND	ND	7	Y # open: 0 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, plants.
101	25	75	47	883	ND	ND	11	Y # open: 0 # total: 4	Y univent	Y ceiling	DEM.
100	4	73	46	544	ND	ND	7	Y # open: 0 # total: 1	Y univent	Y ceiling	DEM.
320	28	74	48	900	ND	ND	8	Y # open: 0 # total: 18	Y ceiling	Y ceiling	
310	5	74	46	662	ND	ND	9	Y # open: 0 # total: 4	Y univent	Y ceiling	DEM, PF.
300	25	73	45	510	ND	ND	11	Y # open: 0 # total: 10	Y ceiling	Y ceiling (off) dust/debris	Hallway DO, Inter-room DO, kiln, DEM.

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									Supply	Exhaust	
108	25	73	45	510	ND	ND	11	Y # open: 0 # total: 10	Y ceiling	Y ceiling (off) dust/debris	Hallway DO, Inter-room DO, DEM, PF.
107	25	75	48	1045	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling (off) dust/debris	DEM, aqua/terra.
106	22	74	47	981	ND	ND	15	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO, DEM.
104	27	74	47	855	ND	ND	8	Y # open: 0 # total: 4	Y univent	Y ceiling (off) dust/debris	DEM.
127	2	75	47	935	ND	ND	9	N	Y ceiling	Y ceiling dust/debris	DEM.
114	21	73	51	853	ND	ND	7	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	DEM.

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MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

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PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

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UF = upholstered furniture

VL = vent location

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
137	1	74	49	838	ND	ND	11	N	Y ceiling	Y ceiling dust/debris	Hallway DO,
117	21	74	48	644	ND	ND	6	Y # open: 2 # total: 4	Y univent	Y ceiling	DEM.
118	2	73	46	488	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling	Hallway DO, DEM, cleaners, plants.
gym	75	73	48	657	ND	ND	5	N	Y ceiling	Y wall	
367 and locker room	12	74	48	671	ND	ND	9	N	Y ceiling	Y ceiling	Hallway DO,
352 health	20	74	50	1234	ND	ND	7	Y # open: 0 # total: 6	Y ceiling	Y ceiling	#WD-CT: 1, #MT/AT: 5, active roof leaks.
373	1	76	47	1044	ND	ND	6	Y # open: 0 # total: 4	Y ceiling	Y ceiling	#WD-CT: 3, 21 occupants gone approx 5 min, active roof leaks.

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

FC = food container

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									Supply	Exhaust	
361	0	75	47	704	ND	ND	4	N	Y ceiling	Y ceiling	
auditorium	0	78	44	493	ND	ND	4	N	Y ceiling	Y wall	active leak stage area corner.
105	21	73	50	1245	ND	ND	5	Y # open: 0 # total: 4	Y univent ceiling	Y ceiling (off)	DEM, cleaners, dehumidifier.
140	2	72	48	574	ND	ND	8	Y # open: 0 # total: 2	Y univent	Y ceiling (off)	Hallway DO, PC.
115	25	73	51	838	ND	ND	8	Y # open: 2 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM, cleaners.
116	21	72	50	897	ND	ND	6	Y # open: 0 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, DEM.
112	24	74	51	847	ND	ND	9	Y # open: 0 # total: 4	Y univent	Y (off)	DEM, plants.

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									Supply	Exhaust	
111	22	74	50	801	ND	ND	8	Y # open: 2 # total: 4	Y univent	Y ceiling dust/debris	Hallway DO, #WD-CT: 1.
cafeteria	1	73	50	622	ND	ND	10	Y # open: 0 # total: 13	Y ceiling	Y ceiling	Hallway DO,
113	29	75	54	995	ND	ND	14	Y # open: 0 # total: 4	Y univent	Y ceiling (off)	Hallway DO,

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Comfort Guidelines

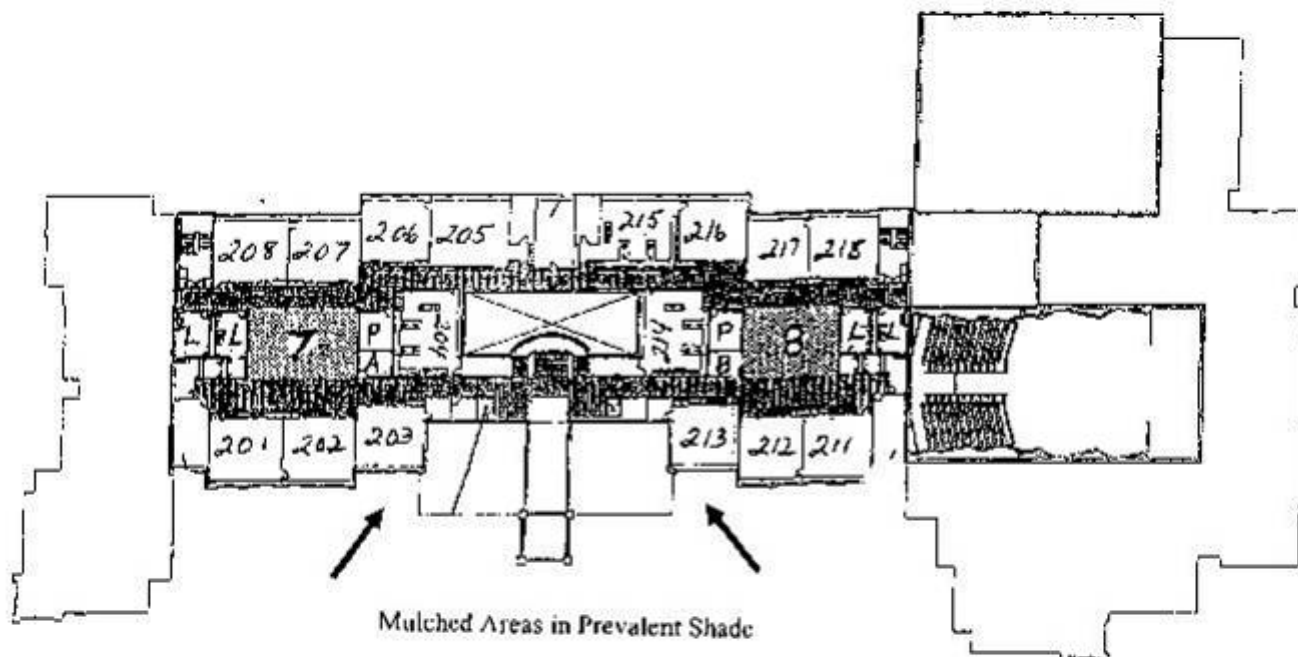
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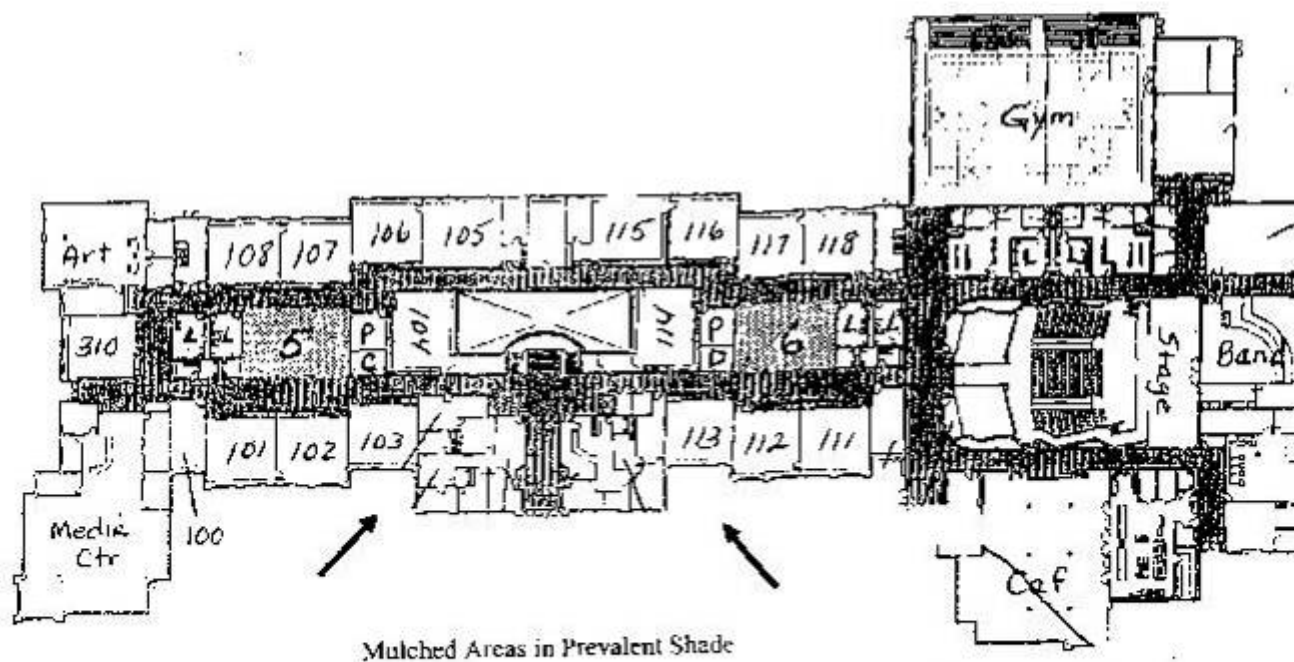
Figure 2
Floor Plan Highlighting Areas of Musty/Mulch Odors

Lynnfield Middle School

Lynnfield, Massachusetts



SECOND FLOOR PLAN



FIRST FLOOR PLAN

